

# Assessment of Benthic Macro-Invertebrates of Freshwater Ecosystem: A Case Study of Ovia River (Iguoriakhi), Edo State, Nigeria

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## Abstract

In this study, the diversity and seasonal variation of benthic macro-invertebrates of Ovia River (Iguoriakhi), Edo State, Southern Nigerian, were studied between July, 2014 and February, 2015. Four stations were selected and sampled monthly and investigated for benthic macro-invertebrates' community structure using basic statistical measurement of abundance and diversity indices to characterize the benthic macro-invertebrates. The species richness, evenness and diversity of the benthic macro-invertebrates in the study area were high and typical of a tropical fast-flowing freshwater river. There was a total of 45 taxa, made up of 1,135 individuals; 10 Ephemeroptera, 10 Diptera, 7 Coleoptera, 7 Odonata, 4 Hemiptera, plasiopora, Haplotaixa, Decapoda, Hydrachnellae, Lepidoptera, Gastropoda, and Trichoptera were represented with a taxa each. The dominant taxa include Ephemeroptera, while the Diptera was the only sub-dominant order identified. Analysis of Variance (ANOVA) revealed that the overall density was significantly different ( $P<0.05$ ) in the study stations. A *posteriori* Duncan Multiple Range (DMR) test indicated that the abundance of Dipterans and Ephemeropterans at station 2 and 4 respectively were the source of the significant difference. The EPT to total ratio indicated that the water quality of all the studied stations were non-impacted. The study concluded that benthic macro-invertebrates are good candidate and less expensive indices for water quality monitoring.

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**Keywords:** Benthic macro-invertebrates, biodiversity, Ovia River, Nigeria

## Introduction

Benthic macro-invertebrates are organism over 1mm in size and these include bottom dwellers which are usually retained by nets or sieves with mesh size of about 0.6mm (Macan, 1959). Benthic macro-invertebrate fauna, often referred to as bottom fauna macro-benthos, are those animals that are associated with or live in the bottom of lakes, ponds, rivers, seas, streams, either crawling, burrowing or attached to various kinds of solid object like boats, canoes, roots of mangrove plants, stones, vegetation, wood and the could be littoral or profundal (Mann, 1980).

Benthic macro-invertebrates are most commonly used tool in biomonitoring. They are invertebrates that inhabit the bottom substrates such as sediments, rocks, snags and aquatic plants, of aquatic habitats for at least part of their life cycle (Sengupta and Dalwani, 2008). There are several advantages of using benthic macro-invertebrates for assessing water quality. According to Sengupta and Dalwani (2008), benthic macro-invertebrates are ubiquitous in rivers and can therefore be affected by environmental disturbances in many different types of aquatic systems and in most habitats/biotopes within these waters. Benthic macro-invertebrates are largely non-mobile and are thus representative of the location being sampled. Their life-span is long enough to allow elucidation of temporal changes caused by disturbances, whilst short enough to ensure observation of recolonisation patterns following such a disturbance. These organisms are also easy to sample and identify. Benthic macro-invertebrates therefore, act as continuous monitors of the water they inhabit (Kalyoncu and Zeybek, 2011), enabling long-term analysis of both regular and intermittent discharges, variable concentrations of pollutants, single and multiple pollutants, and synergistic or antagonistic effects. The use of biota as indicators of stress in the ecosystem has proven successful and indices based on macro-invertebrates assemblages have proven to be useful measures of river health and are widely applied today (Omoigberale and Ogbeibu, 2010; Ogbeibu and Oribhabor, 2002).

Many benthic macro-invertebrates are larval form of flying insects such as mayflies, stoneflies, caddisflies, midge flies etc. The most diverse group of freshwater benthic macro-invertebrates is insects; others are small animals that spend their entire life in streams such as mites and planarians. Some shuttle between water and moist terrestrial environments such as freshwater snail. Benthic macro-invertebrates can be classified as in-fauna and epi-fauna based on immediate substrate of occupation (Cody and Diamond, 1975). In-fauna includes those benthic organisms that are living either buried or burrowing into sediment. Epi-fauna include those that live on the surface of sediments. They are found attached to exposed or submerged object, some are slow moving while others are sedentary.

Apart from their use as long term indicators of water quality, benthic macro-invertebrates have attracted a lot of interest among biologists in view of their importance in food chain of fishes and other vertebrates. These organisms play a vital role in the circulation and recirculation of nutrients in aquatic ecosystems. They constitute the link between the unavailable nutrients in detritus and useful protein materials in fish and shellfish. Most benthic organisms feed on debris that settle on the bottom of the water and in turn serve as food for a wide range of fishes (Imevbore and Bakare, 1970; Idowu and Ugwumba, 2005).

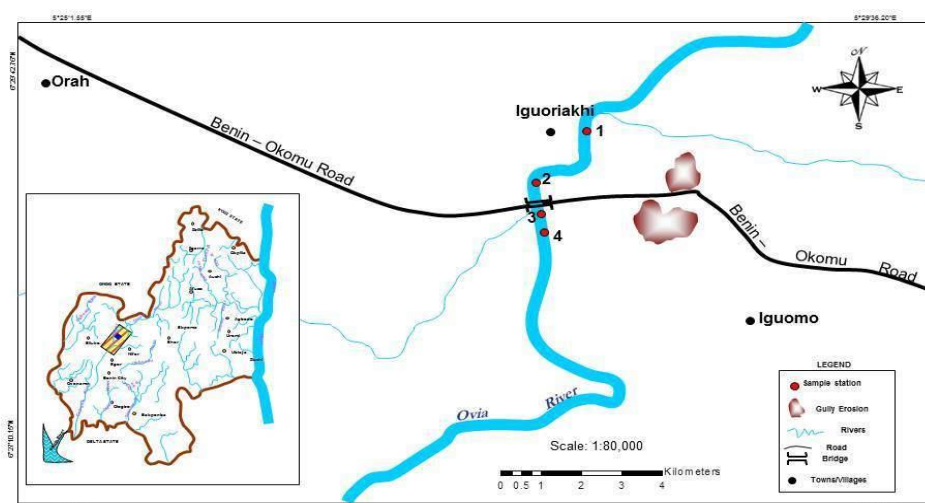
The aim of the present study is to provide some baseline information on the composition, distribution, taxa richness, general diversity and dominance of the benthic macro-invertebrates in the river and also to assess the quality of the water using benthic macro-invertebrates as bio-indicators.

## **MATERIALS AND METHODS**

### **Study site**

The study was carried out within a stretch of Ovia River (Iguoriakhi), which took its source from the Akpata hills in Ekiti State, Nigeria. Iguoriakhi is located about 23.9km from Benin City, off Lagos-Benin Express Road, Nigeria (Lat. 06°23'42.76" – 06°27'10.15"N; Long 005°25'55.0"-005°29'36.20"E), within the tropical rainforest belt of Nigeria. This region has two distinct regions: wet and dry season, which starts from April to October and November to March respectively. The vegetation is predominantly shrubs and trees.

Four sampling stations were selected: 1 and 2 (upstream) and 3 and 4 was designated downstream, each station were about 0.5km apart. Station 1 is located upstream about 1km from a bridge across the river. The station is partially shaded by trees forming a canopy over it. The substratum is a mixture of sandy and decaying organic materials at the bank of the river. Anthropogenic activity is solely fishing. Station 2 is about 0.5km downstream of station 1. The substratum is composed of mud with decaying organic materials at the bank of the river. Human activities include bathing, laundry, dredging, Lumbering and fishing.



**Fig 1:** Map of the study area showing location of Ovia River and the sampling stations, with map of Edo State.

Station 3 is about 1.5km downstream of station 1. The average depth of the river at this station is  $1.45 \pm 0.62\text{m}$ . The current velocity of flow is  $0.71\text{m/s}$ . The major activity here is fishing and farming at the bank of the river. It is characterized by floating macrophytes such as the *Eichhornia crassipes* and *Salvinia* sp. and the bank is made up of grass mats and few palm trees. Station 4 is located about 2km downstream of station 1 (latitude  $6^{\circ} 28' 44.9''\text{N}$  and longitude  $5^{\circ} 27' 43.5''\text{E}$ ). The flow rate is minimal at this station, with mean flowing velocity of  $0.62\text{m/s}$ . The average depth at this station is about  $1.46 \pm 0.48\text{m}$ . The dominant terrestrial vegetation here includes *Elaeis guineensis* and grass vegetation. The activities witnessed here include, fishing only. The substratum composes of decaying plant materials with little organic matter and with clay.

Sampling for Benthic macro-invertebrates, which spanned from July, 2014 to February, 2015 was conducted monthly at the study stations between 0730h and 1100h on each sampling day. The benthic macro-invertebrates were collected by Kick sampling technique (Hynes, 1970; Peterson and Fernando, 1970; Ogbeibu and Victor 1989) and dusting of *Eichhornia crassipes*. The substratum in a known area of  $0.25\text{m}^2$  in each station was vigorously disturbed by kicking for a few minutes. The dislodged organisms in the course of the disturbance were sampled with a hand net made of a cone shaped  $100\mu\text{m}$  mesh size, with a mouth diameter of 20cm and a detachable handle by placing it opposite the flow direction of the river. The dislodged organisms were then washed into the net. Samples collected were sieved with a set of Tyler sieves of mesh sizes 2mm, 1mm, 150um and 100um respectively. The contents retained in the sieves were washed into polypropylene bottle and preserved in

10% formalin. Benthic macro-invertebrates were sorted under a binocular microscope (American Optical Corporation model 570), while identification, counting and drawing were done using an Olympus Vanox Research Microscope Model 230485 (Mag. 50-500x). Identification of specimens of benthic macro-invertebrates was carried out using manuals listed in Ogbeibu and Victor (1989).

## Data Analysis

The benthic macro-invertebrates characterizing and similarities were according to Omoigberale and Ogbeibu (2010). The single factor Analysis of Variance (ANOVA) and Duncan Multiple Range test were used to test for significant difference in the density of benthic macro-invertebrates among stations and to locate site(s) of significant difference respectively. All statistics procedures were adopted from Zar (1984) as well as SPSS 20.00 computer package.

## RESULTS

### CHECKLIST OF BENTHIC MACRO-INVERTEBRATES

The benthic macro-invertebrates comprises of Forty-five (45) taxa consisting of species each of 10 Ephemeroptera, 10 Diptera, 7 Coleoptera, 7 Odonata, 4 Hemiptera, plasiopora, Haplotaixa, Decapoda, Hydrachnellae, Lepidoptera, Gastropoda, and Trichoptera

#### Phylum

#### Annelida

Class: Oligochaeta

Order: Plesiopora

Family: Naididae

*Nais sp.*

Class: Clitellata

Order: Haplotaxida

Family: Lumbricidae

*Eiseniella tetradra*

#### Phylum:

#### Arthropoda

Class: Crustacea

Subclass: Malacostraca

Order: Decapoda

Family: Atyidae

*Caridina africana*

Kingsley, 1882

Class: Arachnida

Order: Hydrachnellae

*Argyroneta aquatica*

Class: Insecta

Order: Ephemeroptera

Family: Caenidae

*Caenis sp.*

Family: Baetidae

*Pseudocloeon sp.*

Klapalek

	<i>Baetis bicaudatus</i>	Leach
	<i>Cloeon simplex.</i>	
	<i>Cloeon cylindroculum</i>	Kimmins
	<i>Centroptilum sp.</i>	Eaton
Family: Adenophlebiodes	<i>Adenophlebiodes</i>	Ulmer
Family: Siphonuridae	<i>Siphonura sp</i>	Needham
Family: Leptophlebiidae	<i>Leptoplebia sp</i>	
Family: Diceromyzidae	<i>Dicercomyzon sp</i>	Demoulin
Order: Coleoptera		
Family: Dytiscidae	<i>Amphiops gibbos</i>	
Family: Hydrophilidae	<i>Philhydrus pectoralis</i>	
Family: Dytiscidae	<i>Deronectes elegaris</i>	
	<i>Dytiscus vertifolis</i>	
Family: Elmidae	<i>Dubiraphia sp.</i>	
Family: Noteridae	<i>Hydrocanthus sp.</i>	
Family: Helmididae	<i>promeresia sp.</i>	
Order: Hemiptera		
Family: Naucoridae	<i>pelocoris femoratus</i>	
Family: Notonectidae	<i>Notonecta unifasciata</i>	
Family: Gerridae	<i>Gerris lacustris</i>	
Family: Belostomatidae	<i>Lethocerus sp</i>	
Order: Lepidoptera		
Family: Crambidae	<i>Nymphula sp</i>	
Order: Diptera		
Family: Chironomidae	<i>Ablabesmyla sp</i>	
	<i>Chironomus fractilobus</i>	Kieffer
	<i>Pentaneura sp</i>	
	<i>Polypedilum sp</i>	Kieffer, 1913
	<i>Tanypus sp</i>	
	<i>Clinotanypus maculatus</i>	
	<i>Cardiocladius sp</i>	
	<i>Procladius sp</i>	

	<i>Tendipes tentans</i>	
Family:	Culicidae	
	<i>Culex</i> sp	
Order:	Odonata	
Sub order:	Anisoptera	
Family:	Corbuliidae	
	<i>Oxygaster curtisil</i>	
Family:	Libellulidae	
Sub family:	Libellulinae	
	<i>Libellula</i> sp	
Family:	Aeshnidae	
	<i>Aeshna</i> sp	
	<i>Erythemis</i> sp	
Sub order:	Zygoptera	
Family:	Lestidae	
	<i>Lestes</i> sp	
Family:	Coenagrionidae	
	<i>Coenagrion scitulum</i>	Rambur
	<i>Enallagma</i> sp.	Charpentier
<b>PHYLUM: MOLLUSCA</b>		
Class:	Gastropoda	
Superfamily:	Ampullarioidea	
Family:	Ampullariidae	
Species:	<i>Pila ovata</i>	

### Benthic macro-invertebrates

Table 1 shows the taxa composition, density and distribution of benthic macro-invertebrates in the study area. Forty-five taxa were identified from a total of 1,135 individuals collected. The major benthic macro-invertebrates include:

**Annelida:** This phylum was represented by 2 species; *Nais* sp and *Eiseniella tetradra* in all stations. *Nais* sp was recorded at stations 1 and 4, while *Eiseniella tetradra* was encountered only at station 1 (Table 2).

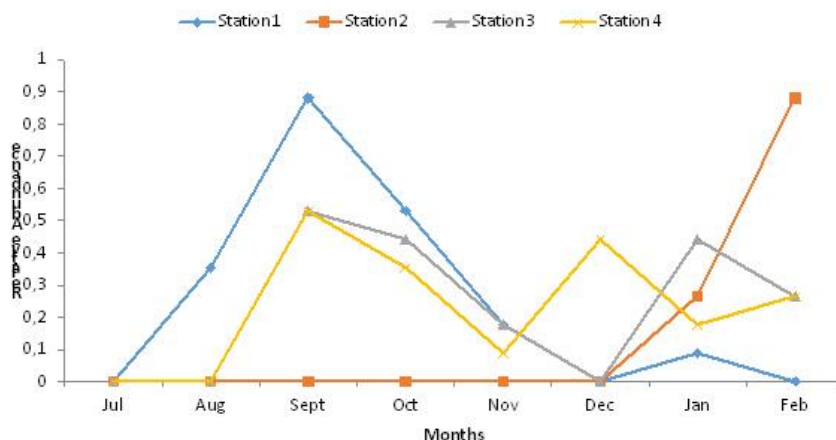
**Diptera:** The family chironomidae was the most important across the study stations, contributing 7.14% to the total density of benthic macro-invertebrates recorded (Fig. 1). The dominant taxon was *pentaneura* sp. It was dominating all the stations. The chironomidae was represented by 9 taxa. Analysis of Variance (ANOVA) revealed that the density of diptera at station 2 was significantly higher ( $P < 0.01$ ) than those in stations 1, 3 and 4 which were not significantly different ( $P > 0.05$ ) from each other (Table 3).

**Table 1: Summary of the physical and chemical parameters of sediment of Ovia River**

	Station 1	Station 2	Station 3	Station 4	p-Value	NESREA	WHO
<b>Parameters</b> (n=29)	(Min-Max) $\bar{x} \pm SD$	(Min-Max) $\bar{x} \pm SD$	(Min-Max) $\bar{x} \pm SD$	(Min-Max) $\bar{x} \pm SD$			
Water Temperature <sup>0</sup> C	(21.00-28.50) 23.94 $\pm$ 4.83	(22.00-28.00) 24.00 $\pm$ 4.78	(20.00-29.00) 25.08 $\pm$ 4.83	(23.00-29.00) 24.75 $\pm$ 5.06	p>0.05	35 <sup>0</sup> C	N/A
pH	(5.20-6.20) 5.78 <sup>a</sup> $\pm$ 0.32	(4.60-5.50) 5.15 <sup>b</sup> $\pm$ 0.33	(4.50-5.90) 5.30 <sup>b</sup> $\pm$ 0.45	(5.30-6.00) 5.73 <sup>a</sup> $\pm$ 0.24	p<0.01	6.5-8.5	6.5-8.5
Electrical Conductivity ( $\mu$ S/cm)	(90.00-250.00) 193.13 <sup>b</sup> $\pm$ 63.30	(260.00-450.00) 367.50 <sup>a</sup> $\pm$ 69.64	(220.00-380.00) 313.75 <sup>a</sup> $\pm$ 53.97	(130.00-280.00) 222.50 <sup>b</sup> $\pm$ 47.13	p<0.01	N/A	1000
Organic Carbon (%)	(0.62-1.50) 1.07 <sup>b</sup> $\pm$ 0.30	(2.11-4.30) 3.35 <sup>a</sup> $\pm$ 0.89	(1.72-2.95) 2.17 <sup>b</sup> $\pm$ 0.51	(0.81-1.57) 1.24 <sup>b</sup> $\pm$ 0.22	p<0.01	NA	NA
Total Nitrogen (%)	(0.06-0.16) 0.10 <sup>b</sup> $\pm$ 0.04	(0.19-0.40) 0.31 <sup>a</sup> $\pm$ 0.08	(0.15-0.29) 0.21 <sup>b</sup> $\pm$ 0.05	(0.07-0.15) 0.12 <sup>b</sup> $\pm$ 0.03	p<0.01	NA	NA
Exchangeable Anions (meq/100g)	(0.30-0.90) 0.61 <sup>b</sup> $\pm$ 0.22	(0.50-1.60) 1.08 <sup>a</sup> $\pm$ 0.38	(0.50-1.30) 0.81 <sup>ab</sup> $\pm$ 0.25	(0.20-0.90) 0.61 <sup>b</sup> $\pm$ 0.25	p<0.01	NA	NA
Sodium (meq/100g)	(0.16-0.89) 0.55 $\pm$ 0.29	(0.42-1.60) 1.09 $\pm$ 0.50	(0.35-1.45) 0.96 $\pm$ 0.48	(0.22-1.15) 0.69 $\pm$ 0.41	p>0.05	200	200
Potassium(meq/100g)	(0.05-0.15) 0.11 <sup>c</sup> $\pm$ 0.03	(0.15-0.40) 0.28 <sup>a</sup> $\pm$ 0.08	(0.10-0.25) 0.17 <sup>b</sup> $\pm$ 0.04	(0.05-0.15) 0.10 <sup>c</sup> $\pm$ 0.03	p<0.01	NA	NA
Calcium (meq/100g)	(0.91-2.00) 1.50 <sup>a</sup> $\pm$ 0.42	(1.76-4.28) 3.35 <sup>a</sup> $\pm$ 1.04	(1.30-3.18) 2.60 <sup>b</sup> $\pm$ 0.74	(1.11-2.35) 1.93 <sup>c</sup> $\pm$ 0.50	p<0.01	NA	NA
Magnesium(meq/100g)	(0.39-0.95) 0.68 <sup>b</sup> $\pm$ 0.21	(0.72-1.38) 1.12 <sup>a</sup> $\pm$ 0.27	(0.39-1.35) 0.97 <sup>ab</sup> $\pm$ 0.38	(0.27-0.95) 0.70 <sup>b</sup> $\pm$ 0.24	p<0.01	NA	NA
Chloride (mg/kg)	(17.70-31.60) 25.50 <sup>c</sup> $\pm$ 5.78	(29.20-55.60) 44.79 <sup>a</sup> $\pm$ 10.16	(22.10-42.90) 36.40 <sup>b</sup> $\pm$ 7.71	(17.70-34.40) 27.66 <sup>c</sup> $\pm$ 6.67	p<0.01	600	NA
Phosphate (mg/kg)	(3.23-6.89) 5.75 <sup>c</sup> $\pm$ 1.41	(7.08-9.82) 8.70 <sup>a</sup> $\pm$ 0.86	(5.49-8.15) 7.20 <sup>b</sup> $\pm$ 0.93	(3.38-7.78) 5.81 <sup>c</sup> $\pm$ 1.46	p<0.01	10	NA
Ammonium Nitrogen (mg/kg)	(1.23-1.95) 1.65 <sup>c</sup> $\pm$ 0.28	(5.16-8.25) 6.69 <sup>a</sup> $\pm$ 1.05	(2.94-8.10) 5.78 <sup>a</sup> $\pm$ 1.72	(1.95-4.20) 3.25 <sup>b</sup> $\pm$ 0.87	p<0.01	NA	NA
Nitrite (mg/kg)	(0.42-1.55) 1.16 <sup>b</sup> $\pm$ 0.38	(1.12-2.89) 1.97 <sup>a</sup> $\pm$ 0.52	(0.98-2.52) 1.71 <sup>a</sup> $\pm$ 0.45	(0.68-1.41) 0.98 <sup>b</sup> $\pm$ 0.27	p<0.01	NA	NA

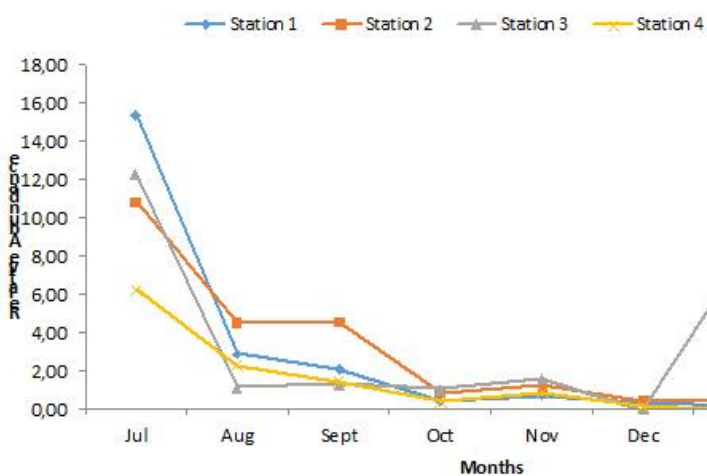


Nitrate (mg/kg)	(1.69-4.00) 3.08 <sup>c</sup> ±0.90	(4.11-6.95) 5.74 <sup>a</sup> ±0.93	(3.64-5.67) 4.49 <sup>b</sup> ±0.92	(1.63-3.62) 3.07 <sup>c</sup> ±0.72	p<0.01	10	NA
Sulphate (mg/kg)	(2.45-5.75) 4.55 <sup>b</sup> ±1.15	(6.12-9.57) 8.01 <sup>a</sup> ±1.12	(5.58- 7.75) 7.10 <sup>a</sup> ±0.84	(2.84-6.48) 4.72 <sup>b</sup> ±1.21	p<0.01	1000	NA
Clay (%)	(3.20-7.91) 5.71 <sup>b</sup> ±1.55	(5.50-10.90) 8.59 <sup>a</sup> ±2.00	(4.30-9.90) 7.13 <sup>ab</sup> ±2.06	(4.80-7.50) 5.34 <sup>b</sup> ±0.90	p<0.01	NA	NA
Silt (%)	(1.30-3.15) 2.46 <sup>b</sup> ±0.61	(2.80-4.90) 3.74 <sup>a</sup> ±0.83	(2.10-2.80) 2.50 <sup>b</sup> ±0.31	(1.60-2.90) 2.44 <sup>b</sup> ±0.42	p<0.01	NA	NA
Sand (%)	(89.10-94.80) 91.80 <sup>a</sup> ±2.01	(77.50-91.20) 86.69 <sup>b</sup> ±4.20	(86.90-93.60) 90.36 <sup>a</sup> ±2.20	(90.00-93.60) 92.13 <sup>a</sup> ±1.12	p<0.01	NA	NA



**Fig 2: Temporal and spatial variations in Diptera at the study stations**

**Ephemeroptera:** The family adenophlebiidae and baetidae dominated the samples at all stations, contributing 22.2% and 77.78% in station 1, 24.07% and 75.93% in station 2, 50.96% and 49.04% in station 3 and 36.97% and 63.03% in station 4. It was represented by 8 taxa from 4 families, Baetidae (5), Adenophlebiidae (1), Leptophlebiidae (1), and Siphonuridae (1). The most dominated taxa were *adenophlebiodes* sp, *cloeon simplex*, and *centroptilum* sp. (Fig.3). They each recorded their highest abundance at stations 3, 2 and 1 respectively. *A posteriori* test for multiple comparison showed that the density of ephemeroptera at station 4 was significantly higher ( $P < 0.01$ ) than those at stations 1, 2, and 3, which were not significantly different from each other (Table 3).



**Fig 3: Temporal and spatial variations in Ephemeroptera at the study stations**

## DISCUSSION

Physico-chemical, geomorphic and biotic characteristic of the aquatic ecosystem are the most significant factors influencing the species composition, abundance and distribution of aquatic benthic macro-invertebrates (Ibemenuga and Inyang, 2006). Bishop (1973) and Dance and Hynes (1980) asserted that water quality and abundance of nutrient were the major factors governing the abundance and distribution of benthic macro-invertebrates fauna in aquatic environment.

A total of 45 species comprising of 1,135 individuals shared within 3 phyla, 6 classes, 11 orders and 32 families were recorded in this study. This recorded species richness is similar to some of works carried out in a similar pattern by: Victor and Ogbeibu (1991); Ogbeibu and Victor (1989); Victor and Onomivbori (1996) and Ogbeibu and Oribhabor (2002) at Ikpoba River. This result varied from a total of 23 species identified by Umeozor (1995) at the new Calabar River; 30 species belonging to 20 families and 5 classes recorded by Hart and Zabbey (2005) at Woji Creek in the upper reaches of Bonny River in the Lower Niger Delta; 14 species representing 11 families of macro invertebrates identified by Sikoki and Zabbey (2005) at Imo River; 19 species belonging 4 phyla, 6 classes and 12 families were identified by George *et al.* (2009) at Okpoka creek during the study and 28 species identified by Ezekiel *et al.* (2011) at Sombreiro River, Niger Delta. These differences are attributable to difference in location, time, nutrient availability and prevailing physical and chemical characteristics of these aquatic bodies. The variable substrate composition (sand, mud, silt, debris/organic detritus, stones etc.) and aquatic macrophyte provided different microhabitats for the diverse groups of the fauna. Organisms cannot survive without adequate food for the organisms' survival and growth (Ibemenuga and Inyang, 2006). The account of dominant taxa which include Ephemeroptera and Diptera in this study have been in the documentation by Ogbeibu and Orihabor (2002) at Ikpoba River ; Olomukoro and Ezemonye (2006) in assessment of the macro-invertebrate fauna of rivers in southern Nigeria; Olomukoro and Azubuike (2009) at Ekpan Creek, Warri. The occurrence of Ephemeroptera (Baetidae) and Diptera (Chironomidae) have been reported to be common and major components of tropical streams (Victor and Ogbeibu, 1989; Ogbeibu and Victor, 1989; Victor and Al-Mahrouqi, 1996).

Ephemeropterans appeared at all stations; the density was most and least felt at stations 3 and 4 respectively. The ephemeropterans encountered in this study have earlier been recorded by Ogbeibu and Victor (1989), Ogbeibu and Oribhabor, (2002) at Ikpoba River, Edokpayi and Ekikhalo (2001) at Ibiekuma River, Omoigberale and Ogbeibu (2010) at Osse River. The qualitative presence of Ephemeroptera in almost all the water bodies in Edo State as being spectacular has being acknowledged (Olomukoro and

Ezemonye 2006). Contrary to the documentations by Ogbeibu and Oribhabor (2002) and Omoigberale and Ogbeibu (2010) which recognized *Baetis tricaudatus* and *Baetis bicaudatus* respectively as most dominant ephemeropterans at the various study rivers, *Adenophlebiodes* sp. was recorded as the most dominant ephemeropterans in this study. *Cloeon simplex* and *Centropilum* sp. which are current loving were encountered visually at all the stations. Significant correlation was recorded between members of the family Baetidae and Caenidae with total hydrocarbon content of the sediment. The dominance of the dipterans with respect to number of individuals and species is in agreement with the reports of Victor and Ogbeibu (1989), Ogbeibu and Oribhabor (2002), Ogbeibu and Oribhabor (2002), Ibemenuga and Inyang (2006), Edokpayi *et al.* (2010). The dominance of dipterans in the system as in other aquatic ecosystems may be attributed to their morphological and physiological adaptations to the various habitats, availability of food and sustained reproduction (Mbah and Vijime, 1989; Umeham, 1989). Chironomids which were among the invertebrates that accounted most in the overall abundance of the dipterans are known to colonize all kinds of environments including polluted waters. They hardly show any habitat restriction (Victor and Ogbeibu, 1991) and are known to replace other invertebrate taxa in streams perturbed by human activity. This is due to their ability to extract oxygen from water of very low oxygen concentration. The presence of the dipterans was felt at all stations; their density varies across the study stations. The variable substrate composition which provided different microhabitats and nutrient variability may be responsible for this density differences. Significant inverse correlation was recorded between members of the family Chironomidae and the sediments nitrite concentration; probably reduction in the concentration of these NO<sub>2</sub> leads increase in the density of chironomids.

The trichopterans were sparsely represented among the study stations; this probably resulted from high sensitivity of these organisms to organic pollution. Species of annelid recorded in this study have been documented by Olomukoro and Ezemonye (2006); Omoigberale and Ogbeibu (2010). Members of the order Plesiopora were represented by *Nais* sp. and *Eiseniella tetradra* which were also sparsely represented this was in contrast to the overall abundance of annelids in aquatic ecosystem that was recognized by Omoigberale and Ogbeibu (2010). The annelids identified in this study were not among the enlisted species recognized by Ajao and Fagade (1991) and George *et al.*, (2010). Decapoda had been recognized to be intolerant to induced environmental disturbance Ogbeibu and Oribhabor (2002). Species of decapods recognized in this study have been documented by Ogbeibu and Oribhabor (2002) at Ikpoba River, Omoigberale and Ogbeibu (2010) at Osse River, Olomukoro and Ezemonye (2006) in the study of aquatic invertebrates

at Southern Nigeria. Abundance and taxa richness of the order of Odonata encountered in this study were unevenly distributed across the station. Their presence were felt most at stations 4 and most of the Odonata identified in this study have been in the literatures documented by Olomukoro and Ezemonye (2006); Omoigberale and Ogbeibu (2010). The rest of the benthic macro-invertebrates which include decapods, hemipterans and coleopterans identified in this study have been documented most of the above referenced scientists.

**Table 2: Abundance and Distribution of Benthic macro-invertebrates at the study stations**

	Station 1	Station 2	Station 3	Station 4
<b>ANNELIDA</b>	-	-	-	-
<b>Plesiopora</b>	-	-	-	-
<i>Nais</i> sp	1	-	-	1
<b>Haplotaxida</b>	-	-	-	-
<i>Eiseniella tetradra</i>	1	-	-	-
<b>ARTHROPODA</b>	-	-	-	-
<b>Decapoda</b>	-	-	-	-
<i>Caridina africana</i>	2	2	1	-
<b>Hydrachnellae</b>	-	-	-	-
<i>Argyroneta aquarica</i>	1	-	1	-
<b>Trichoptera</b>	-	-	-	-
<i>Agraylea</i> sp.	-	-	1	-
<b>Ephemeroptera</b>	-	-	-	-
<i>Adenophlebiodes</i> sp.	52	52	133	44
<i>Cloeon cylindrolum</i>	-	5	2	3
<i>Leptoplebia</i> sp.	3	-	-	-
<i>Siphonura</i> sp.	2	1	-	2
<i>Cloeon simplex</i>	28	72	22	13
<i>Pseudocloeon</i> sp.	-	-	8	-
<i>Baetis</i> sp	52	-	8	13
<i>Centroptilum</i> sp	97	86	88	44
<i>Caenis</i> sp	23	16	-	3
<i>Diceromyzon</i> sp	-	36	35	8
<b>Coleoptera</b>	-	-	-	-
<i>Amphiops gibbos</i>	2	-	-	-
<i>Philhydrus pectoralis</i>	4	-	1	2
<i>Deronectes elegaris</i>	1	-	-	-
<i>Dytiscus vertifolis</i>	-	1	29	1
<i>Dubiraphia</i> sp.	1	-	-	-
<i>Hydrocanthus</i> sp	-	-	-	2
<i>Promeresia</i> sp	-	-	1	-
<b>Hemiptera</b>	-	-	-	-
<i>Pelocoris femoratus</i>	-	2	3	1
<i>Notonecta unifasciata</i>	-	-	1	-

<i>Gerris lacustris</i>	-	1	-	-
<i>Lethocerus</i> sp.	-	2	-	-
<b>Lepidoptera</b>	-	-	-	-
<i>Nymphula</i> sp.	-	1	-	-
<b>Diptera</b>	-	-	-	-
<i>Ablabesmyla</i> sp	12	3	2	2
<i>Chironomus fractilobus</i>	-	2	3	2
<i>Pentaneura</i> sp	10	8	16	14
<i>Polypedilum</i> sp.	1	-	-	-
<i>Tanypus</i> Sp.	-	-	-	1
<i>Polypedilum</i> sp	-	-	1	-
<i>Clinotanypus maculates</i>	-	-	1	-
<i>Cardiocladius</i> sp.	-	-	-	1
<i>Procladius</i> sp	-	-	-	-
<i>Tendipes tentans</i>	-	-	-	1
<i>Culex</i> sp.	-	-	3	-
<b>Odonata</b>	-	-	-	-
<i>Oxygaster curtisil</i>	-	-	-	2
<i>Libellula</i> sp	-	-	-	2
<i>Aeshna</i> sp	1	-	-	2
<i>Erythemis</i> sp	-	-	-	1
<i>Lestes</i> sp	3	7	4	5
<i>Enallagma</i> sp.	2	1	-	2
<i>Coenagrion Scitulum</i>	1	1	1	-
<b>MOLLUSCA</b>	-	-	-	-
<b>Gastropoda</b>	-	-	-	-
<i>Pila ovata</i>	-	-	1	-
Number of species (S)	22	19	22	25
Numbers of Individuals (N)	300	299	364	172
Dominance (D)	0.18	0.19	0.21	0.15
Diversity (H)	2.07	1.97	1.97	2.35
Equitability (J)	0.67	0.67	0.64	0.73
Evenness (E)	0.36	0.38	0.33	0.42
Species richness (Margalef)	3.68	3.16	3.56	4.66

Species diversity is known to be highly variable in rivers with response to disturbance, nutrients availability and the presence of suitable habitat (Fowler, 2002). Higher diversity also results when many species have equal or near-equal opportunity of co-existence. Mckintosh (2000), in support of this, observed that in the absence of disturbance, community composition may be strongly influenced by biotic interactions such as competition and predation. A decrease in diversity and corresponding increase in abundance of a limited number of species is a common community response to environmental disturbance. The diversity and evenness of species calculated

by Shannon-Wiener function varied among the study stations. Station 4 had the highest diversity index as calculated by Shannon-Wiener function; this reflects the evenly distribution of these organisms encountered at this station. The high evenness and low dominance index justify this situation, since the higher the evenness the higher the diversity, and the lower the dominance index, the higher the diversity (Victor and Ogbeibu 1989).

**Table 3: Summary of Taxa Composition and Test of Significant Difference**

		Station 1	Station 2	Station 3	Station 4	Chi-Square	p-Value
Dominant	Ephemeroptera	257 <sup>a</sup>	268 <sup>a</sup>	296 <sup>a</sup>	130 <sup>b</sup>	68.51	p<0.01
Subdominant	Diptera	23 <sup>a</sup>	13 <sup>b</sup>	21 <sup>a</sup>	21 <sup>a</sup>	16.69	p<0.01
Rare	Rare Taxa	20 <sup>b</sup>	18 <sup>b</sup>	47 <sup>a</sup>	21 <sup>b</sup>	21.32	p<0.01
Total		300 <sup>a</sup>	299 <sup>a</sup>	364 <sup>a</sup>	172 <sup>b</sup>	68.46	p<0.01

The benthic macro-invertebrates' comparisons of the four stations clearly showed that station 3 and station 4 have the highest and lowest abundance respectively which can be attributed to nutrient availability, response to disturbance and the presence of suitable habitats.

From biological analyses of the studied water body with spatial environmental conditions, it is concluded that benthic macro-invertebrates are good candidates to be used as bio-monitoring of water quality and environmental conditions of freshwater bodies.

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